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Collecting Field Data in a Small Boat Harbor for a Multiphase Numerical Study

by Thad C. Pratt

PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) describes methods and techniques for acquiring measurements of currents, tidal fluctuations, sediment bed material, aerial photography, and structural topography on a coastal structure. The case study described herein involved measurements obtained in Tedious Creek, MD. Work was performed as part of the Monitoring Completed Navigation Projects Program.

BACKGROUND: High-quality field measurements are an integral part of the design process for new and existing engineering projects. A key to success in modeling is a field measurement program to obtain as much information as possible about key input parameters. Carefully collected, high-resolution field measurements yield valuable insights to aid in the interpretation of processes active in a project area.

This CHETN describes the methods, techniques, and instrument configurations that were employed to obtain field measurements suitable for estimating water-level fluctuations, channel geometry, bed-material classification, tidal currents, and marsh-line definition in a numerical study looking at hydrodynamic conditions in a small boat harbor. The study intends to evaluate the performance of the breakwater in front of the small boat harbor and look at sedimentation issues as they relate to shoreline degradation and channel maintenance dredging. Tedious Creek is located in Maryland, approximately 32.2 km (20 miles) south of Cambridge, at Crocheron, a small rural community. Tedious Creek opens up into a small bay, connected to Fishing Bay, which in turn ties into Chesapeake Bay (Figure 1).

DATA COLLECTION

There are several methods for data collection. They include the following:

a. Positioning and datum referencing using Trimble Real-Time Kinematic (RTK)-Global Positioning System (GPS).
b. Aerial photography.
c. Tidal data collection.
d. Hydrographic and jetty surveying.
e. Bottom sample collection.
f. Acoustic Doppler Current Profiler (ADCP) data collection/processing.

Positioning and datum referencing. Locating and verifying horizontal and vertical control is an important part of any data collection effort. At this location, the vertical control was suspect because of local subsidence. There are several benchmarks that have anchor points driven to a point of refusal in the area. The National Ocean Service (NOS) Web site, *http://co-ops.nos.noaa.gov/*,

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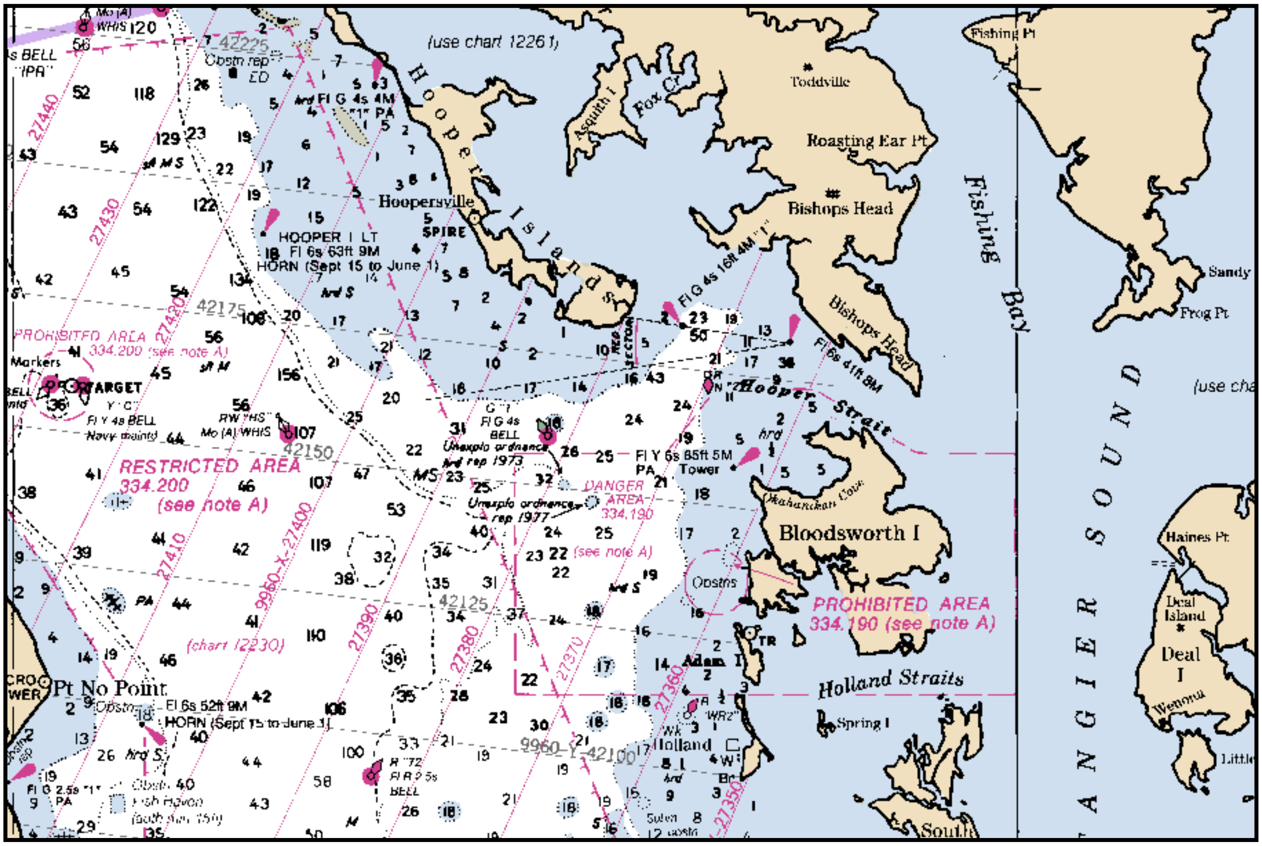

Figure 1. Tedious Creek project area

provides users the necessary monument descriptions and locations within a project area. Sometimes these benchmarks are hard to actually find, so it is advisable to get the descriptions of as many as possible in the area (see Figure 2).

The construction benchmarks near the jetty structure were surveyed to these NOS tidal benchmarks using a RTK-GPS system. This was done to check the validity of the construction benchmarks and to determine the appropriate offsets for locating the GPS base station on site while conducting all survey operations. These offsets would also provide a check in future surveys in the area to monitor subsidence at the site since the first order points are driven to a point of refusal.

Aerial photography. The targets were first priority because so many factors are involved in obtaining good aerial photography. The preflight logistics of setting viewable targets had to be complete so, when the weather was appropriate, at the right stage of the tide, the aerial crew could collect data. The aerial targets were painted on road intersections around the job site using white paint. The roads in the area were very light colored, so the targets were outlined with black paint. This procedure defined the targets better for processing. The targets were made from two lines that crossed at right angles; the lines were 0.61 m (2 ft) wide and 3.05 m (10 ft) long. The black paint was used to make a 10-cm- (4-in.-) wide border completely around the perimeter of the target (Figure 3). Target center positions were surveyed using RTK-GPS after all locations were painted and complete.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service

TIDAL BENCHMARKS

Station ID: 8571559 PUBLICATION DATE: 09/26/2000
Name: MCCREADYS CREEK, FISHING BAY, MARYLAND
NOAA Chart: 12261 Latitude: 38° 18.0' N
USGS Quad: WINGATE Longitude: 76° 0.4' W

BENCHMARK STAMPING: 1559 B 1981
DESIGNATION: 857 1559 B

MONUMENTATION: Benchmark disk VM#: 3066
AGENCY: National Ocean Service (NOS) PID:
SETTING CLASSIFICATION: Stainless steel rod

The benchmark is a disk located near the picnic area, 65.5 m (215 ft) NW of the north end of the west bulkhead for the boat ramp, 27.52 m (90.3 ft) west of the center line of the road leading to McCreadys Point, 4.54 m (14.9 ft) WNW of the NE corner of the concrete slab for the shaded picnic area, and 4.15 m (13.6 ft) ENE of the NW corner of the concrete slab for the picnic area. The benchmark is crimped to the top of a stainless steel rod driven 17.1 m (56 ft) to refusal.

BENCHMARK STAMPING: 1559 C 1981
DESIGNATION: 857 1559 C

MONUMENTATION: Benchmark disk VM#: 3067
AGENCY: National Ocean Service (NOS) PID:
SETTING CLASSIFICATION: Stainless steel rod

The benchmark is a disk located along the entrance road to McCreadys Point, 58.00 m (190.3 ft) NNW of the north end of the asphalt parking area, which is parallel to the north end of the shaded picnic area, and 4.33 m (14.2 ft) east of the center line of the road. The benchmark is crimped to the top of a stainless steel rod driven 19.2 m (63 ft) to refusal.

BENCHMARK STAMPING: 1559 D 1981
DESIGNATION: 857 1559 D

MONUMENTATION: Benchmark disk VM#: 3068
AGENCY: National Ocean Service (NOS) PID:
SETTING CLASSIFICATION: Stainless steel rod

The benchmark is a disk located along the road leading to McCreadys Point, 63.4 m (208 ft) NNW of Benchmark 1559 C 1981 and 3.84 m (12.6 ft) east of the center line of the road. The benchmark is crimped to the top of a stainless steel rod driven 16.2 m (53 ft) to refusal.

Figure 2. Tidal benchmark descriptions

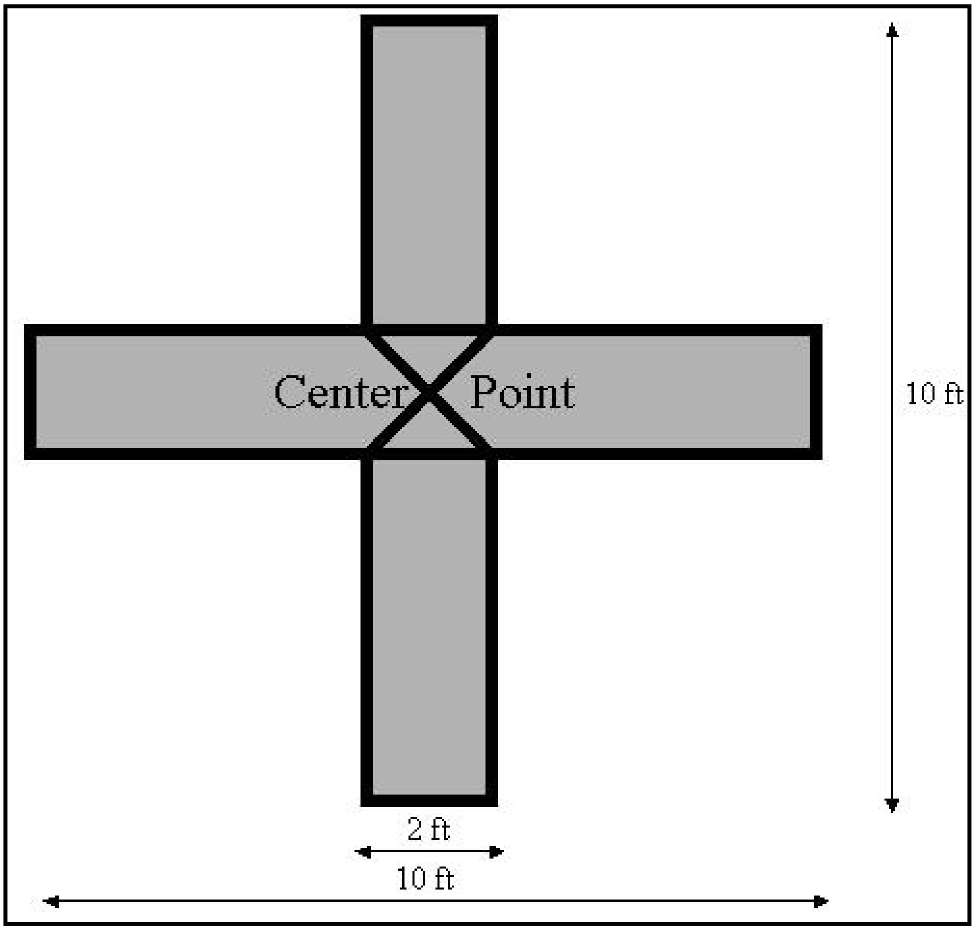

Figure 3. Aerial targets

Targets were located throughout the survey region at road intersections. In order to rectify an image, the user must have points as spatially diverse as possible. Ideally, a point in each corner of the image gives excellent results.

The aerial photographer happened to be working in the vicinity of this project, so mobilization costs were minimal. Typically, mobilization costs are almost as much as collecting and processing the data. It is advisable to call several contractors in the area and see if an existing or planned job is in progress. This will reduce the cost of collecting the data. The intended use of these data was to define the wetted perimeter at an instant in time and monitor the shoreline degradation by comparing surveys from out years. If the shoreline position changed significantly between subsequent surveys, then the erosion or deposition rates could be estimated. The degree of accuracy of the data usually drives the cost of the collection and dictates the methodology employed. Since meter-level accuracy was all that was necessary for the modeling requirements, standard aerial photographic techniques were employed. Figure 4 shows the final product delivered by the aerial photographer.

Figure 4. Aerial mosaic of Tedious Creek over flight data

Tide data. Pressure tide gages were deployed near both ends of the bay (Figure 5). Custom aluminum mounting brackets were fixed to stationary piles to deploy the gages. Once deployed, the elevation to the top of each gage was established using the RTK-GPS. These mini-tides were programmed to collect changes in water elevation every 15 min. During processing, the established elevation and the change in the water surface are used to process the hydrographic data. These data can also be used to produce an accurate graph of the tidal cycle (Figure 6).

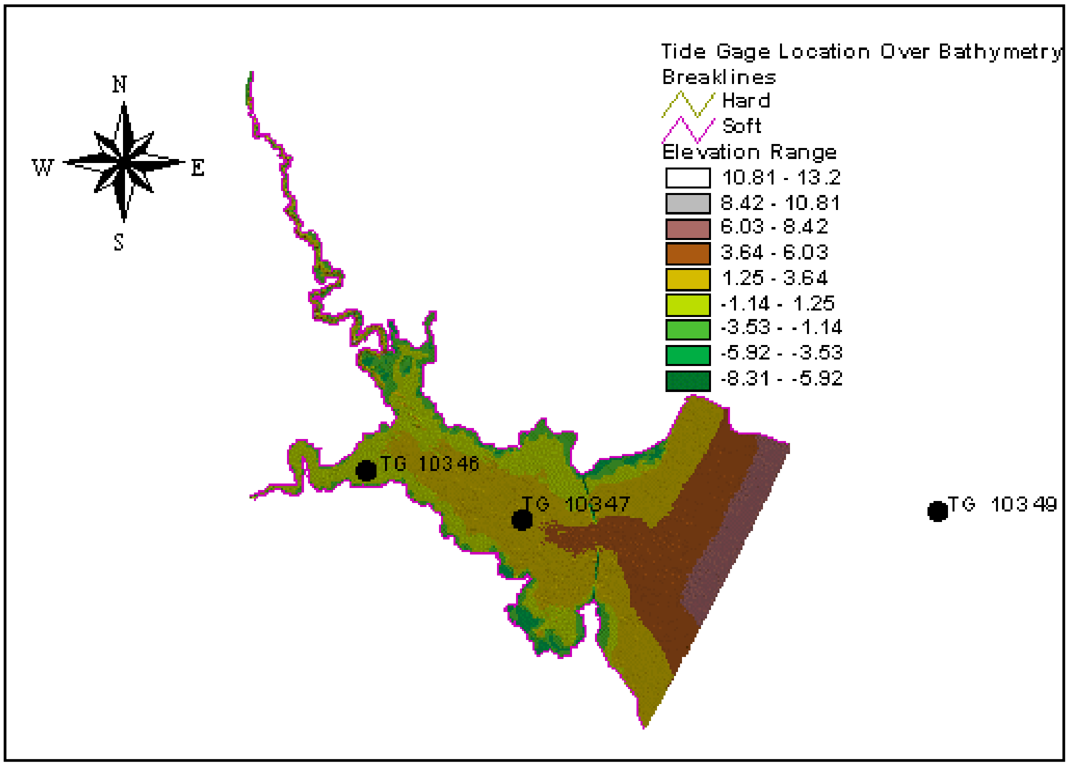

Figure 5. Tide station locations in May 2001 deployments

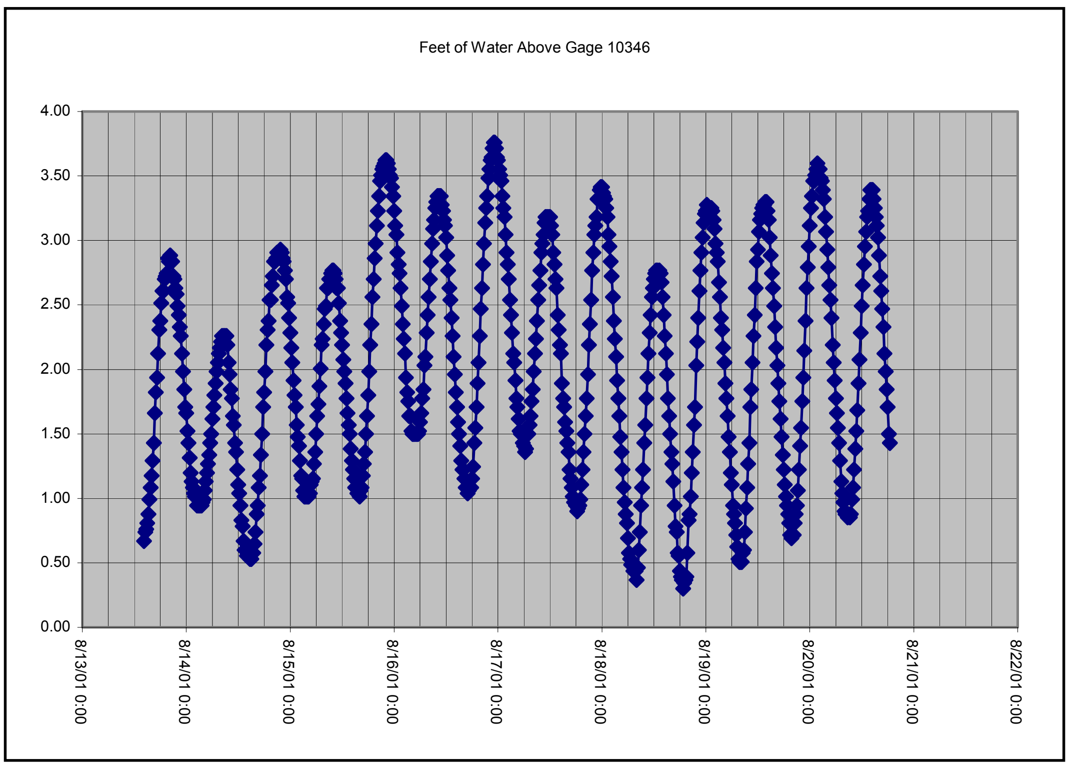

Figure 6. Water surface fluctuation at Gage 10346

Hydrographic surveying. A flat-bottom, 5.5-m (18-ft) survey vessel was used to collect bathymetry data. This vessel was chosen for its shallow draft and ease of use for all aspects of this job. The boat was equipped with GPS (for positioning), an Odom Hydrotrac Fathometer (for depth), and a laptop computer using HyPACK (hydrographic data collection software). The hydro crew collected data along lines that had predetermined positions. The lines were drawn digitally, in the survey program, onto maps provided by the local U.S. Army Corps of Engineers District. The hydro crew drove the boat along each line collecting both position and depth data simultaneously. While collecting hydro data, the crew was able to watch its position along the lines and keep watch for any problems. Figure 7 shows the collection lines for the bathymetry data. The line density around the jetties and channel areas was increased to better define the bathymetry.

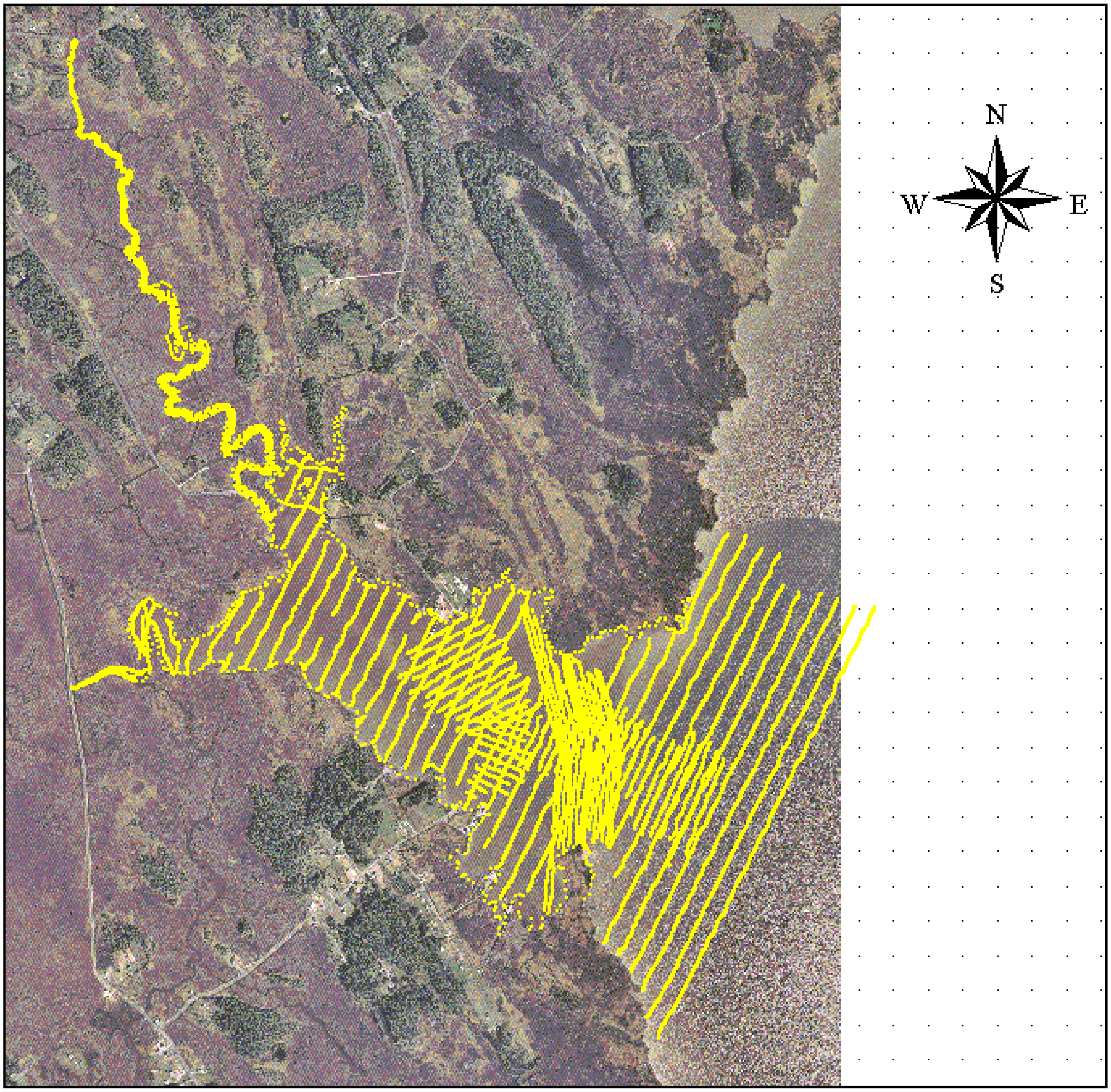

Figure 7. Bathymetry line locations

Figure 8 is a contour of the bathymetry data collected along the lines shown in Figure 7. This contour was produced inside the Hydraulic Processes Analysis System (HyPAS) (Pratt and Cook 1999) after the data had been imported.

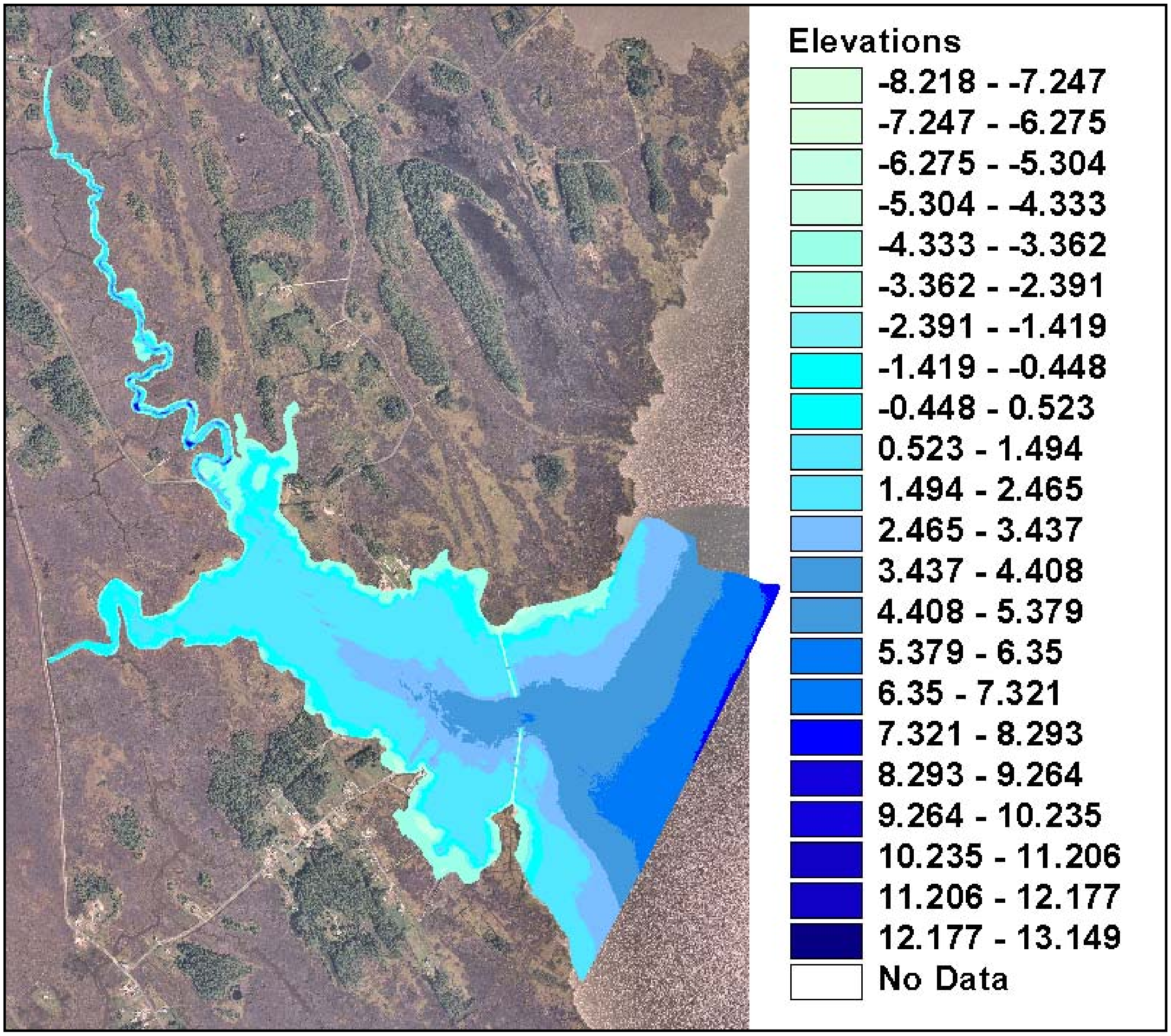

Figure 8. Resulting bathymetry contour

Bank-line definition. The survey vessel was used to transport personnel around the perimeter of the Tedious Creek area. A member of the field crew stood on the front of the boat with the RTK-GPS unit and, as the boat pulled into the bank, would collect a data point at the water line. These bank-line data were collected approximately every 15.2 m (50 ft) around the perimeter of the bay. Figure 9 shows the point density around the perimeter of the bay and along the rock jetties.

Figure 9. Jetty survey point locations and bank-line definition

Rock jetty survey. Surveying the jetty was an important part of this project. There were concerns that the jetties were settling. The ability to return to the jetty at a later date and shoot in the same point on each stone was important. This would be possible by using the GPS program and a hand-held computer shown in Figure 10, but a visual method was also needed. Paint might not survive as long as needed so construction adhesive was used at each measurement location. Everywhere a data point was collected a "blob" of adhesive was placed and then a circle was painted around the point. On future surveys, it will be possible to return to the exact point and collect comparison data. Data were collected along the entire length of both jetties with cross sections every 6.1 m (20 ft) as shown in Figure 9.

Figure 10. Jetty survey team using RTK-GPS gear with construction adhesive and paint as a marker point

Bottom samples and bed-material classification. Bottom samples were part of the fieldwork on the Tedious Creek project. Sixty-four bottom samples were collected using a clamshell sampler (Figure 11).

Figure 11. Clamshell bed sampler

The samples were stored in 1-gal ziplock freezer bags for shipment back to the laboratory for grain-size analysis. Standard sieve analysis was performed on these samples. The sample locations were scattered throughout the project area to define the spatial variability of sediment types. Figure 12 shows the layout of the sampling plan.

The sediment data were imported into the HyPAS Geographic Information System (GIS) for analysis and plotting. The sediment toolbox was used to generate the gradation curves seen in Figure 13. This toolbox allows the user to look at all the samples in relation to other data types--bathymetry, velocity, and aerial photography.

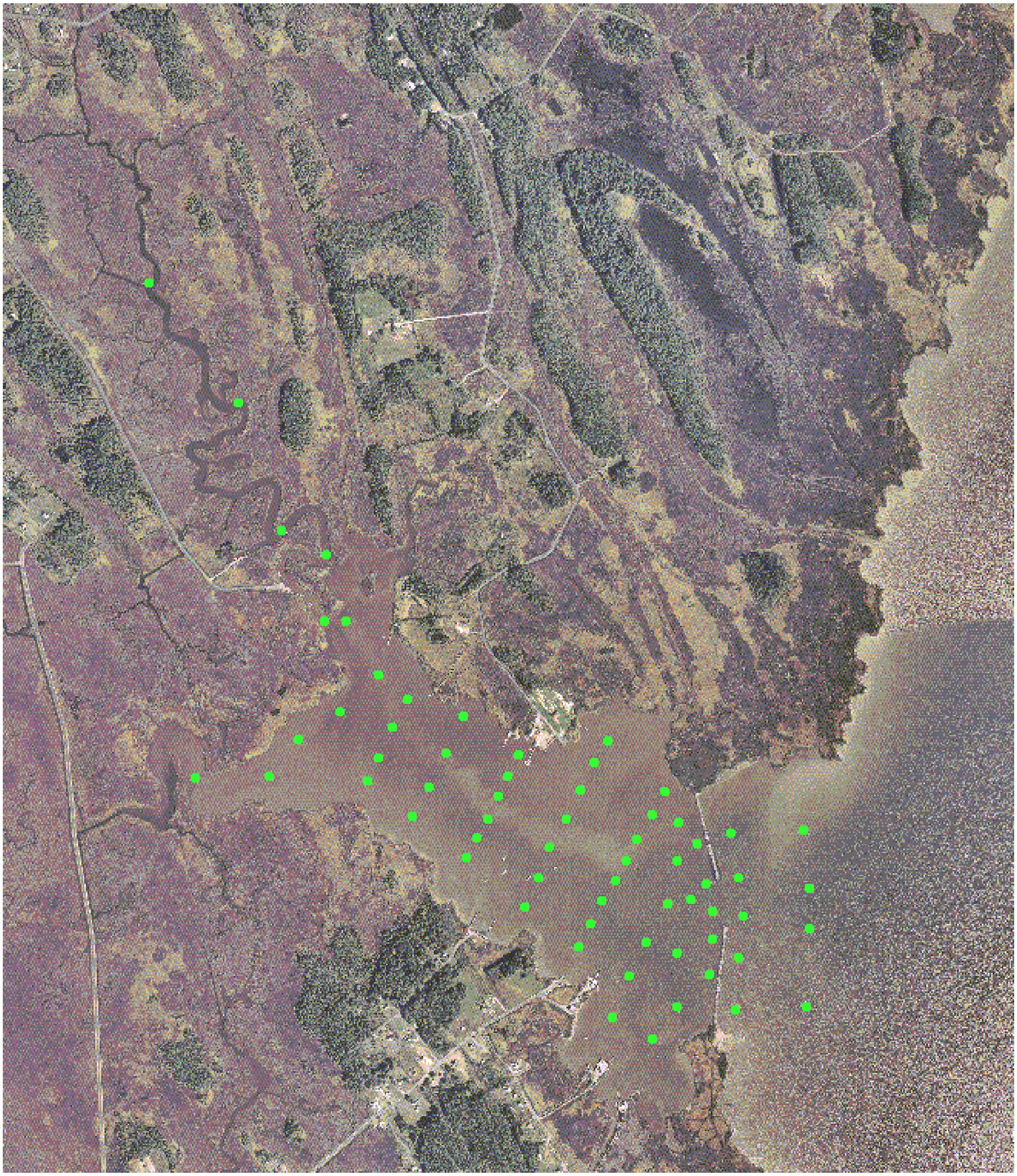

Figure 12. Bed material sample plan

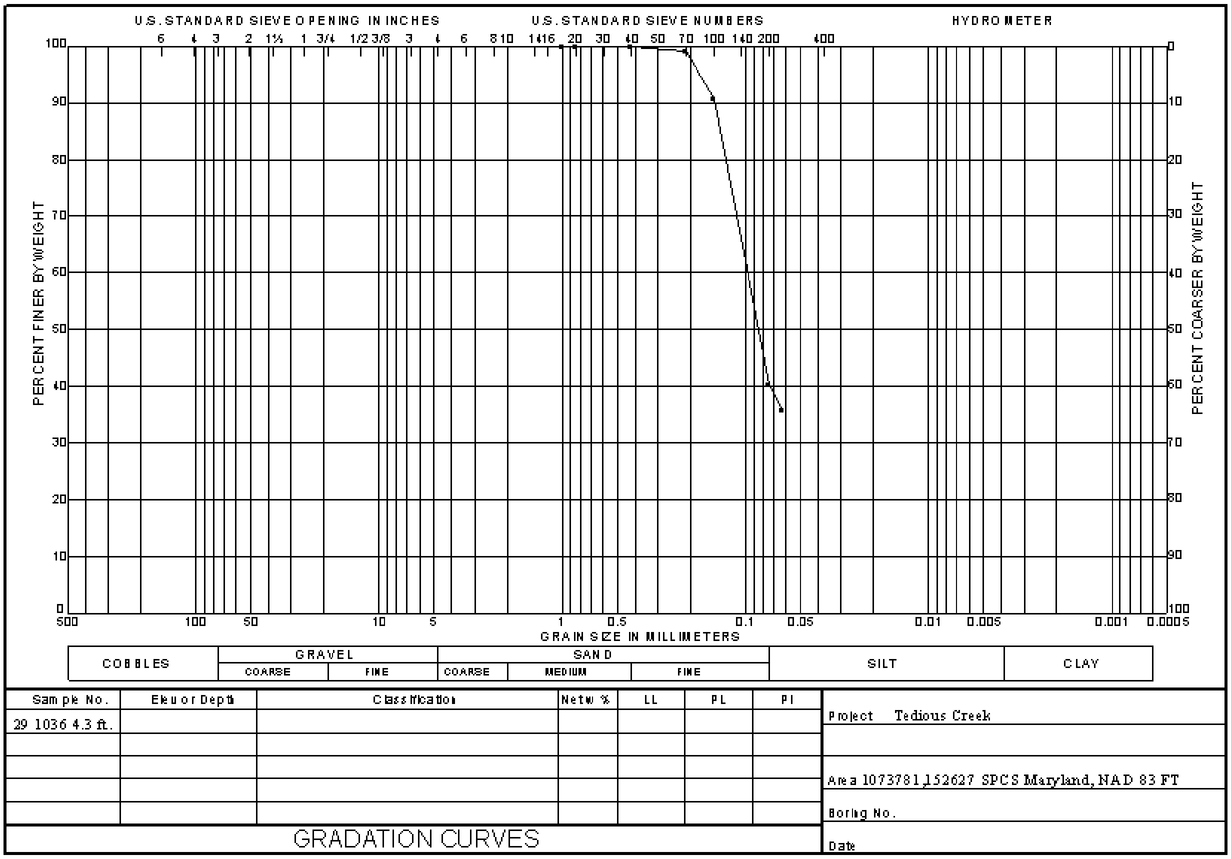

Figure 13. Gradation curve generated from sieve analysis

ADCP velocity data. The ADCP survey involved running three separate lines in the job area as shown in Figure 14. Each line was run one time each hour for the 13-hr time period. The intent was to capture the flow conditions throughout a tidal cycle at critical points in the system. The modeler needed to know the total discharge into the system from Tedious Creek and Fishing Bay. The center line was to capture eddies generated from the flood jet as it entered the small bay. All of the velocity data for each of the 13-hr data sets were imported into HyPAS for plotting and model comparison.

HyPAS allows for model solution file data to be imported into the GIS project. Then both the model data and ADCP data can be plotted in the same coordinate system using the same legend scales. This is useful in making detailed comparisons of these data types to model results. Since the ADCP data are three-dimensional in nature and usually of a much greater resolution than model data, they need to be processed to match the same vertical and horizontal scales as the model data before a comparison can be made. HyPAS affords the user the option of horizontal and vertical averaging at fixed spatial values as specified by the user. Figure 15 shows one time-step from the model solution file and the corresponding data set from the 13-hr survey.

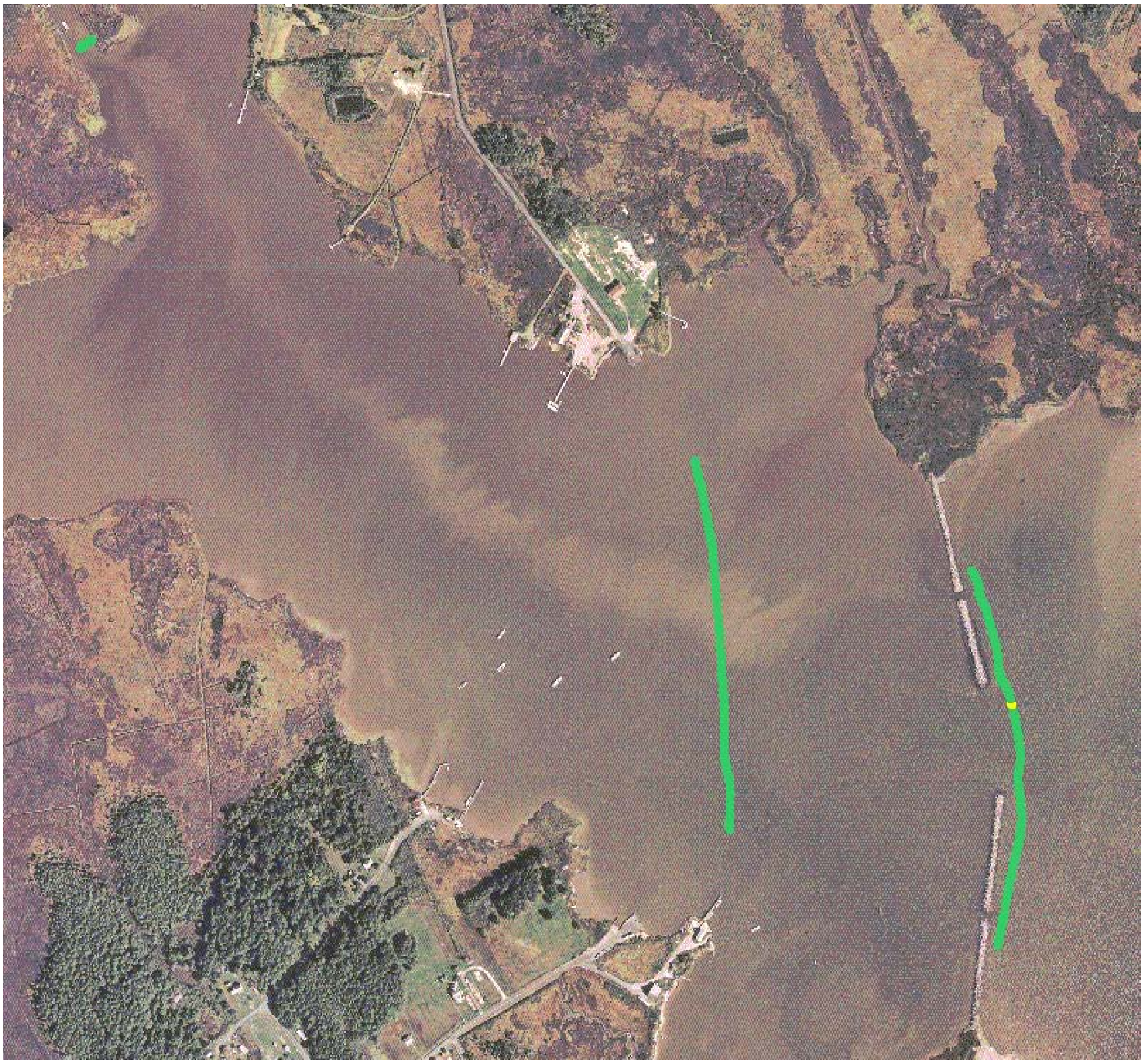

Figure 14. ADCP line locations for the 13-hr survey

The red vectors are from the model results while the black vectors are from the field data. The identify feature in ArcView allows the user to select both vectors when the themes are active. All of the descriptive information defining the vectors is displayed for the user. It is apparent that the direction is correct, but the magnitude of the model data is still about 50 percent of the field data. With comparisons like this, the modeler has the information needed to make necessary adjustments in the model to produce results that match the field data.

ADDITIONAL INFORMATION: For further information, contact Mr. Thad C. Pratt, U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory (Voice: 601-6342959, e-mail: Thad.C.Pratt@erdc.usace.army.mil). For information about the Monitoring Completed Navigation Projects Program, contact Dr. Lyndell Z. Hales, Lyndell.Z.Hales@usace.army.mil Any mention of a commercial product does not constitute an endorsement by the Federal government.

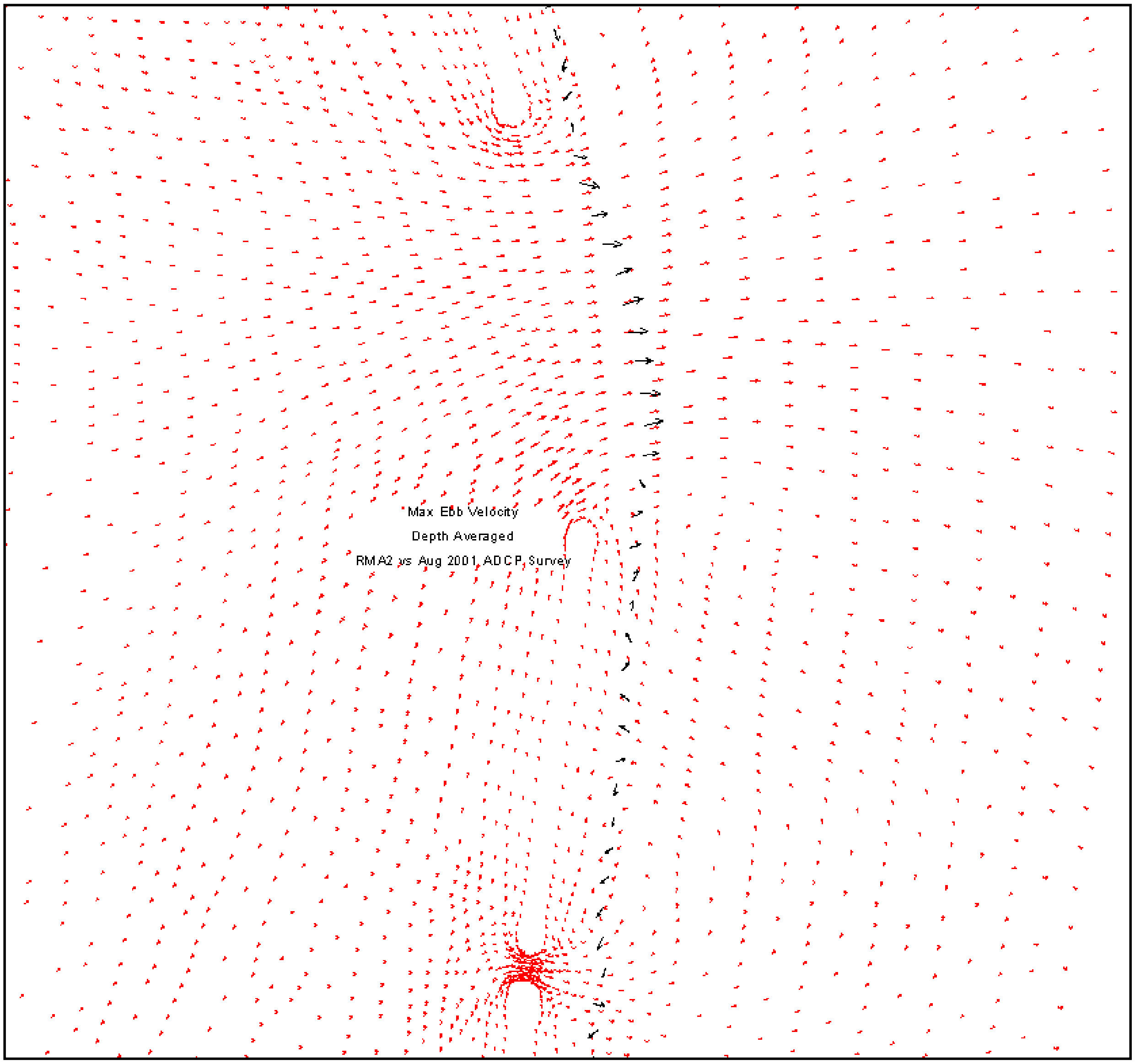

Figure 15. ADCP field data and model data comparison

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Pratt, T. C., Fagerburg, T. L., and McVan, D. C. (1999). "Field data collection at coastal inlets," Coastal Engineering Technical Note CETN-IV-24, U.S. Army Engineer Research and Development Center, Vicksburg, MS, *http://chl.wes.army.mil/library/publications/chetn/*.